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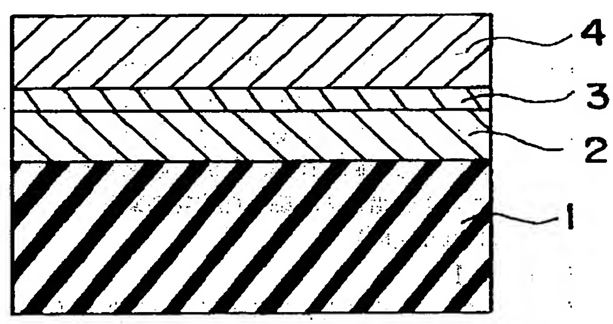
(54)【発明の名称】　交換結合膜および磁気抵抗効果素子

(57)【要約】
【課題】　大きな交換結合力が得られる交換結合膜、およびこのような交換結合膜を有し安定した出力を長期間にわたって得ることのできる磁気抵抗効果素子を提供する。
【解決手段】　Ｆｅ，Ｃｏ，Ｎｉの少なくとも１種からなる強磁性体膜（２）と反強磁性体膜（４）とを積層した構造を有する交換結合膜において、強磁性体膜と反強磁性体膜との界面に、元素添加された強磁性体からなる中間膜（３）を介在させて格子マッチングの改善により交換結合力を向上した交換結合膜、およびこの交換結合膜とこの交換結合膜を構成する強磁性体膜に電流を通電するための電極とを具備した磁気抵抗効果素子。



【特許請求の範囲】
【請求項１】　Ｆｅ，ＣｏおよびＮｉからなる群より選択される少なくとも１種の元素からなる強磁性体膜と、反強磁性体膜とを積層した構造を有する交換結合膜において、上記強磁性体膜と上記反強磁性体膜との界面に、Ｆｅ，ＣｏおよびＮｉからなる群より選択される少なくとも１種の元素と、Ｂ，Ａｌ，Ｃａ，Ｓｃ，Ｃｕ，Ｓｒ，Ｒｈ，Ｐｄ，Ａｇ，Ｌａ，Ｃｅ，Ｐｒ，Ｙｂ，Ｉｒ，Ｐｔ，Ａｕ，Ｐｂ，Ｌｉ，Ｔｉ，Ｒｂ，Ｖ，Ｚｒ，Ｋ，Ｃｒ，Ｎｂ，Ｍｏ，Ｂａ，Ｎｄ，Ｅｕ，Ｔａ，Ｗ，Ｃ，Ｚｒ，Ｃｄ，Ｍｇ，Ｙ，Ｔｃ，Ｒｕ，Ｇｄ，Ｔｂ，Ｄｙ，Ｈｏ，Ｅｒ，Ｔｍ，Ｌｕ，Ｈｆ，Ｒｅ，Ｏｓ，Ｔｌ，Ｎａ，ＩｎおよびＧａからなる群より選択される少なくとも１種の元素とを含有する強磁性体からなる中間膜を介在させたことを特徴とする交換結合膜。
【請求項２】　上記強磁性体膜と上記反強磁性体膜との界面に介在させる中間膜が、下記一般式
$(Co_X Fe_Y Ni_Z)_{100-a} M_a$
（ここで、０≦Ｘ≦１，０≦Ｙ≦１，０≦Ｚ≦１，Ｘ＋Ｙ＋Ｚ＝１，０≦ａ≦５０であり、ＭはＢ，Ａｌ，Ｃａ，Ｓｃ，Ｃｕ，Ｓｒ，Ｒｈ，Ｐｄ，Ａｇ，Ｌａ，Ｃｅ，Ｐｒ，Ｙｂ，Ｉｒ，Ｐｔ，Ａｕ，Ｐｂ，Ｌｉ，Ｔｉ，Ｒｂ，Ｖ，Ｚｒ，Ｋ，Ｃｒ，Ｎｂ，Ｍｏ，Ｂａ，Ｎｄ，Ｅｕ，Ｔａ，Ｗ，Ｃ，Ｚｒ，Ｃｄ，Ｍｇ，Ｙ，Ｔｃ，Ｒｕ，Ｇｄ，Ｔｂ，Ｄｙ，Ｈｏ，Ｅｒ，Ｔｍ，Ｌｕ，ＨｆＲｅ，Ｏｓ，Ｔｌ，Ｎａ，ＩｎおよびＧａからなる群より選択される少なくとも１種の元素である。）で表されることを特徴とする請求項１記載の交換結合膜。
【請求項３】　上記中間膜の組成が連続的に変化することを特徴とする請求項１記載の交換結合膜。
【請求項４】　上記中間膜の組成が段階的に変化することを特徴とする請求項１記載の交換結合膜。
【請求項５】　請求項１記載の交換結合膜と、上記交換結合膜を構成する強磁性体膜に電流を通電する電極とを具備したことを特徴とする磁気抵抗効果素子。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、強磁性体膜と反強磁性体膜との交換結合を利用する交換結合膜、およびこの交換結合膜を具備した磁界検出用センサや再生用磁気ヘッドなどの磁気抵抗効果素子に関する。
【０００２】
【従来の技術】従来より高密度磁気記録における再生用ヘッドとして、磁気抵抗効果素子を用いた磁気ヘッドの研究が進められている。現在、磁気抵抗効果素子材料としては８０ａｔ％Ｎｉ－２０ａｔ％Ｆｅ合金（いわゆるパーマロイ）薄膜が用いられている。近年、これに代わる材料として巨大磁気抵抗効果を示す$(Co/Cu)_n$などの人工格子膜やスピンバルブ膜が注目されている。しかし、これらの材料からなる磁気抵抗効果膜は磁区を持つため、これに起因するバルクハウゼンノイズが実用化の上で大きな問題となっており、磁気抵抗効果膜を単磁区化する方法が種々検討されている。その１つに強磁性体である磁気抵抗効果膜と反強磁性体膜との交換結合を利用して磁気抵抗効果膜の磁区を特定方向に制御する方法がある。このような反強磁性体材料としてはγ－ＦｅＭｎ合金が広く知られている（例えば、米国特許第４１０３３１５号および米国特許第５０１４１４７号）。また、巨大磁気抵抗効果が得られるスピンバルブ膜においては、反強磁性体膜はこれと接する強磁性体膜の磁化を固定する役割を果たす。この磁化の固定力すなわち交換結合力の大きさは、スピンバルブ膜を再生ヘッド部に用いた磁気ヘッドにおける再生出力の大きさに大きく関ってくる。しかし、現在までに用いられている強磁性体膜と反強磁性体膜との組み合わせでは大きな交換結合力が得られず、その結果十分な再生出力が得られないなどの問題があった。
【０００３】
【発明が解決しようとする課題】上述したように、強磁性体膜と反強磁性体膜との交換結合を利用する交換結合膜は、例えば磁気抵抗効果素子のバルクハウゼンノイズの低減、スピンバルブ膜の磁化の固着などに応用されているが、それほど大きな交換結合力が得られないという問題があった。
【０００４】本発明の目的は、大きな交換結合力が得られる交換結合膜、およびこのような交換結合膜を有し、安定した出力を長期間にわたって得ることのできる磁気抵抗効果素子を提供することにある。
【０００５】
【課題を解決するための手段】本発明の交換結合膜は、Ｆｅ，ＣｏおよびＮｉからなる群より選択される少なくとも１種の元素からなる強磁性体膜と、反強磁性体膜とを積層した構造を有する交換結合膜において、上記強磁性体膜と上記反強磁性体膜との界面に、Ｆｅ，ＣｏおよびＮｉからなる群より選択される少なくとも１種の元素と、Ｂ，Ａｌ，Ｃａ，Ｓｃ，Ｃｕ，Ｓｒ，Ｒｈ，Ｐｄ，Ａｇ，Ｌａ，Ｃｅ，Ｐｒ，Ｙｂ，Ｉｒ，Ｐｔ，Ａｕ，Ｐｂ，Ｌｉ，Ｔｉ，Ｒｂ，Ｖ，Ｚｒ，Ｋ，Ｃｒ，Ｎｂ，Ｍｏ，Ｂａ，Ｎｄ，Ｅｕ，Ｔａ，Ｗ，Ｃ，Ｚｒ，Ｃｄ，Ｍｇ，Ｙ，Ｔｃ，Ｒｕ，Ｇｄ，Ｔｂ，Ｄｙ，Ｈｏ，Ｅｒ，Ｔｍ，Ｌｕ，Ｈｆ，Ｒｅ，Ｏｓ，Ｔｌ，Ｎａ，ＩｎおよびＧａからなる群より選択される少なくとも１種の元素とを含有する強磁性体からなる中間膜を介在させたことを特徴とするものである。本発明の磁気抵抗効果素子は、上記交換結合膜と、上記交換結合膜を構成する強磁性体膜に電流を通電する電極とを具備したことを特徴とするものである。
【０００６】
【発明の実施の形態】以下、本発明を詳細に説明する。

本発明の交換結合膜において、強磁性体膜はＦｅ，ＣｏおよびＮｉからなる群より選択される少なくとも１種の元素からなるものであり、一般式$Co_X Fe_Y Ni_Z$（$0 \leqq X \leqq 1$，$0 \leqq Y \leqq 1$，$0 \leqq Z \leqq 1$，$X+Y+Z=1$）で表される。より具体的には、$Co_{0.9}Fe_{0.1}$、$Ni_{0.8}Fe_{0.2}$、Ｃｏなどが挙げられる。本発明の交換結合膜において、反強磁性体膜としては例えばγ－ＦｅＭｎ合金、ＮｉＯ、ＮｉＭｎ合金、ＩｒＭｎ合金が挙げられる。これらの強磁性体膜と反強磁性体膜とは少なくとも部分的に積層されて、交換結合していればよい。

【０００７】本発明の交換結合膜の特徴的な構成は、強磁性体膜と反強磁性体膜との界面に、強磁性膜の構成元素であるＦｅ，ＣｏおよびＮｉからなる群より選択される少なくとも１種の元素と、これ以外の添加元素Ｍとを含有する強磁性体膜からなる中間膜を設けたことにある。ここで、添加元素Ｍとしては、Ｂ，Ａｌ，Ｃａ，Ｓｃ，Ｃｕ，Ｓｒ，Ｒｈ，Ｐｄ，Ａｇ，Ｌａ，Ｃｅ，Ｐｒ，Ｙｂ，Ｉｒ，Ｐｔ，Ａｕ，Ｐｂ，Ｌｉ，Ｔｉ，Ｒｂ，Ｖ，Ｚｒ，Ｋ，Ｃｒ，Ｎｂ，Ｍｏ，Ｂａ，Ｎｄ，Ｅｕ，Ｔａ，Ｗ，Ｃ，Ｚｒ，Ｃｄ，Ｍｇ，Ｙ，Ｔｃ，Ｒｕ，Ｇｄ，Ｔｂ，Ｄｙ，Ｈｏ，Ｅｒ，Ｔｍ，Ｌｕ，Ｈｆ，Ｒｅ，Ｏｓ，Ｔｌ，Ｎａ，ＩｎおよびＧａからなる群より選択される少なくとも１種が用いられる。

【０００８】この中間膜を構成する強磁性体は、下記一般式

$$(Co_X Fe_Y Ni_Z)_{100-a} M_a$$

（ここで、$0 \leqq X \leqq 1$，$0 \leqq Y \leqq 1$，$0 \leqq Z \leqq 1$，$X+Y+Z=1$，$0 \leqq a \leqq 50$である。）で表される。より具体的には、$(Co_{0.9}Fe_{0.1})_{100-a}M_a$、$(Ni_{0.8}Fe_{0.2})_{100-a}M_a$、$Co_{100-a}M_a$、$Fe_{100-a}M_a$などが挙げられる。添加元素Ｍの添加量ａは５０ａｔ％以下であり、２ａｔ％以上３０ａｔ％以下であることがより好ましい。

【０００９】この中間膜は、強磁性体膜と反強磁性体膜との界面に介在することにより、膜間の格子マッチングを向上させる作用を有し、これによって大きな交換結合力が得られる。上述した添加元素Ｍは、耐食性、交換結合力、ブロッキング温度の改善にとっても好ましい成分である。特に上述した添加元素のうちＰｄ，Ｃｕ，Ｐｔ，Ａｕ，Ａｇは、抵抗変化率に対する影響を最小限度に抑えられる観点から好ましい元素である。

【００１０】本発明において中間膜は、反強磁性体膜との界面において格子マッチングが良好になるという条件を満たせば、組成変調型であってもよい。例えば、中間膜中において添加元素Ｍの組成が連続的に変化してもよいし、所定の膜厚で段階的に変化してもよい。この場合、反強磁性体膜側の界面において、添加元素Ｍの添加量が最大になっていればよい。一般的に強磁性体膜に元素添加を行うと磁化が減少したりキュリー温度が低下したりするが、上記のように反強磁性体膜側の界面において添加元素Ｍの添加量が最大になるように制御すれば、強磁性体膜の特性の劣化を最小限に抑えることができる。また、本発明の強磁性膜を２種以上積層した形態でもよい。

【００１１】本発明の交換結合膜では、強磁性体膜および反強磁性体膜の膜厚は、それぞれ強磁性および反強磁性を発現する範囲であれば特に限定されない。ただし、大きな交換結合力を得るためには、反強磁性体膜の膜厚が強磁性体膜の膜厚よりも厚いことが望ましい。また、中間膜の膜厚も特に限定されず、少なくとも一原子層だけ存在していればよい。

【００１２】本発明の交換結合膜は、蒸着法、スパッタ法、ＭＢＥ法など公知の成膜方法を用いて所定の基板上に形成される。この際、反強磁性体膜と強磁性体膜との結合に一方向異方性を付与するために、磁界中で成膜するかまたは熱処理を行ってもよい。

【００１３】基板は特に限定されず、ガラス、樹脂などの非晶質基板、Ｓｉ，ＭｇＯ，Al_2O_3、各種フェライトなどの単結晶基板、配向基板、焼結基板などを用いることができる。また、反強磁性体膜や強磁性体膜の結晶性を向上させるために、基板上に１～１００ｎｍの厚さの下地層を設けてもよい。下地層は結晶性を向上させるものであれば特に限定されないが、例えばＰｄやＰｔなどの貴金属、ＣｏＺｒＮｂなどの非晶質金属、面心立方構造を持つ金属や合金を用いることができる。

【００１４】本発明の磁気抵抗効果素子は、上述した交換結合膜に対し、少なくとも強磁性体膜に電流を通電するための電極を設けたものである。電極としては、例えばＣｕ，Ａｇ，Ａｕ，Ａｌやこれらの合金が用いられる。電極は強磁性体膜に直接接触してもよいし、反強磁性体膜を介して形成されていてもよい。

【００１５】本発明の磁気抵抗効果素子は、上述したように大きな交換結合力が得られる交換結合膜を具備しているので、磁界検出用センサー、再生用磁気ヘッドなどに用いた場合に大きな再生出力が得られる。

【００１６】なお、本発明の磁気抵抗効果素子において、反強磁性体膜と強磁性体膜との交換結合力は強磁性体膜におけるバルクハウゼンノイズ除去、人工格子膜やスピンバルブ膜に対する磁化固着などに利用することもできる。

【００１７】

【実施例】以下、本発明の実施例を図面を参照して説明する。

実施例１

ＲＦマグネトロンスパッタ装置を用い、基板を加熱していない状態で磁界中成膜することにより、図１に示す構造を有する交換結合膜を作製した。具体的には、表面がＣ面であるサファイア基板１上に、$Co_{90}Fe_{10}$の組成を有する膜厚４ｎｍの強磁性体膜２、$(Co_{0.9}Fe_{0.1})_{90}M_{10}$で表される組成を有する強磁性体からなる

膜厚１ｎｍの中間膜３、$Fe_{50}Mn_{50}$の組成を有する膜厚１５ｎｍの反強磁性体膜４を順次形成した。中間膜３の添加元素Ｍとして、それぞれＢ，Ａｌ，Ｃａ，Ｓｃ，Ｃｕ，Ｓｒ，Ｒｈ，Ｐｄ，Ａｇ，Ｌａ，Ｃｅ，Ｐｒ，Ｙｂ，Ｉｒ，Ｐｔ，Ａｕ，Ｐｂ，Ｌｉ，Ｔｉ，Ｒｂ，Ｖ，Ｚｒ，Ｋ，Ｃｒ，Ｎｂ，Ｍｏ，Ｂａ，Ｎｄ，Ｅｕ，Ｔａ，Ｗ，Ｃ，Ｚｒ，Ｃｄ，Ｍｇ，Ｙ，Ｔｃ，Ｒｕ，Ｇｄ，Ｔｂ，Ｄｙ，Ｈｏ，Ｅｒ，Ｔｍ，Ｌｕ，Ｈｆ，Ｒｅ，Ｏｓ，Ｔｌ，Ｎａ，ＩｎまたはＧａを用いた。

【００１８】得られた交換結合膜について、結晶構造とその配向方位をＸ線回折により調べた。その結果、結晶構造は面心立方構造であり、（１１１）配向した膜であることが確認された。

【００１９】図２に得られた交換結合膜の磁化容易軸方向（成膜時の磁界方向）の磁化曲線ａおよび磁化困難軸方向の磁化曲線ｂを示す。図２において、ｃの値が交換結合力を示す交換バイアス磁界（Ｈｕａ）である。

【００２０】図３に、上述したそれぞれの添加元素Ｍを添加した中間膜を有する各交換結合膜、および中間膜を設けていない交換結合膜について測定された交換バイアス磁界の値を示す。この図に示されるように、中間膜を有する交換結合膜は、中間膜を設けていない交換結合膜よりも、交換結合力が大きいことがわかる。

【００２１】実施例２

実施例１と同様の方法により図１に示す構造を有する交換結合膜を作製した。本実施例では、表面がＣ面であるサファイア基板１上に、$Co_{90}Fe_{10}$の組成を有する膜厚３ｎｍの強磁性体膜２、$(Co_{0.9}Fe_{0.1})_{100-a}Pd_{a}$（ａ＝５，１０，１５，２０，２５，３０）で表される組成を有する強磁性体からなる膜厚２ｎｍの中間膜３、$Fe_{50}Mn_{50}$の組成を有する膜厚１５ｎｍの反強磁性体膜４を順次形成した。

【００２２】図４に中間膜におけるＰｄの添加量ａと交換バイアス磁界との関係を示す。図４から、Ｐｄの添加量ａが増加するのに伴って交換結合力が増加することがわかる。

【００２３】図５に中間膜におけるＰｄの添加量ａと中間膜の格子定数との関係を示す。図５から、Ｐｄの添加量ａが増加するのに伴って中間膜の格子定数が反強磁性体膜である$Fe_{50}Mn_{50}$の格子定数に近づいていることがわかる。

【００２４】実施例３

実施例１と同様の方法により図６に示す構造を有する交換結合膜を作製した。本実施例においては、サファイア基板１上に、$Co_{90}Fe_{10}$の組成を有する膜厚４ｎｍの強磁性体膜２、$(Co_{0.9}Fe_{0.1})_{90}Ta_{10}$で表される組成を有する強磁性体からなる膜厚１．５ｎｍの中間膜１１、$(Co_{0.9}Fe_{0.1})_{80}Ta_{20}$で表される組成を有する強磁性体からなる膜厚１．５ｎｍの中間膜１２、$Fe_{50}Mn_{50}$の組成を有する膜厚１５ｎｍの反強磁性体膜４を順次形成した。

【００２５】図３に本実施例で得られた交換結合膜の交換バイアス磁界の値を併記する。本実施例のように中間膜として組成が段階的に変化する組成変調膜を用いた場合、大きな交換結合力が得られることがわかる。

【００２６】実施例４

実施例１と同様の方法により図１と類似の構造を有する交換結合膜を作製した。本実施例においては、サファイア基板１上に、$Co_{90}Fe_{10}$の組成を有する膜厚２ｎｍの強磁性体膜２、$(Co_{0.9}Fe_{0.1})_{100-a}Nd_{a}$で表される組成を有し、Ｎｄ組成ａが強磁性体膜２側でａ＝１、反強磁性体膜４側でａ＝２０となるように連続的に変化させた強磁性体からなる膜厚３ｎｍの中間膜３、$Fe_{50}Mn_{50}$の組成を有する膜厚１５ｎｍの反強磁性体膜４を順次形成した。

【００２７】図３に本実施例で得られた交換結合膜の交換バイアス磁界の値を併記する。本実施例のように中間膜として組成が連続的に変化する組成変調膜を用いた場合、大きな交換結合力が得られることがわかる。

【００２８】実施例５

実施例１と同様の方法により図１に示す構造を有する交換結合膜を作製した。本実施例では、表面がＣ面であるサファイア基板１上に、$Ni_{80}Fe_{20}$の組成を有する膜厚４ｎｍの強磁性体膜２、$(Ni_{0.8}Fe_{0.2})_{90}M_{10}$で表される組成を有する強磁性体からなる膜厚１ｎｍの中間膜３、$Fe_{50}Mn_{50}$の組成を有する膜厚１５ｎｍの反強磁性体膜４を順次形成した。中間膜３の添加元素Ｍとして、それぞれＢ，Ａｌ，Ｃａ，Ｓｃ，Ｃｕ，Ｓｒ，Ｒｈ，Ｐｄ，Ａｇ，Ｌａ，Ｃｅ，Ｐｒ，Ｙｂ，Ｉｒ，Ｐｔ，Ａｕ，Ｐｂ，Ｌｉ，Ｔｉ，Ｒｂ，Ｖ，Ｚｒ，Ｋ，Ｃｒ，Ｎｂ，Ｍｏ，Ｂａ，Ｎｄ，Ｅｕ，Ｔａ，Ｗ，Ｃ，Ｚｒ，Ｃｄ，Ｍｇ，Ｙ，Ｔｃ，Ｒｕ，Ｇｄ，Ｔｂ，Ｄｙ，Ｈｏ，Ｅｒ，Ｔｍ，Ｌｕ，Ｈｆ，Ｒｅ，Ｏｓ，Ｔｌ，Ｎａ，ＩｎまたはＧａを用いた。

【００２９】図７に、上述したそれぞれの添加元素Ｍを添加した中間膜を有する各交換結合膜、および中間膜を設けていない交換結合膜について測定された交換バイアス磁界の値を示す。この図に示されるように、中間膜を有する交換結合膜は、中間膜を設けていない交換結合膜よりも、交換結合力が大きいことがわかる。

【００３０】実施例６

本実施例では通常の半導体プロセスを用いて加工を行い、図８に示す磁気抵抗効果素子を作製した。具体的には、シリコン基板２１表面に形成された熱酸化膜２２の上に、膜厚４０ｎｍの$Co_{83}Pt_{17}$ハード膜２３を成膜した後、その一部を選択的に除去して下地の熱酸化膜２２を部分的に露出させた。その上に膜厚１０ｎｍの$Co_{88}Zr_{5}Nb_{7}$膜２４、膜厚２ｎｍの$Ni_{80}Fe_{20}$膜２５、膜厚４ｎｍの$Co_{90}Fe_{10}$強磁性体膜２６、膜厚３ｎｍのＣｕ膜２７、膜厚２ｎｍの$Co_{90}Fe_{10}$強磁性体

膜２８、膜厚１ｎｍの（$Co_{0.9}Fe_{0.1}$）$_{90}Pb_{10}$中間膜２９、膜厚１５ｎｍの$Fe_{50}Mn_{50}$反強磁性体膜３０、膜厚２０ｎｍのＴｉ保護膜３１を順次成膜した。さらに膜厚２０μｍのＣｕ電極３２を成膜して加工した。

【００３１】なお、磁界中で熱処理を行った後、ハード膜２３を着磁し、反強磁性体膜３０と中間膜２９および強磁性体膜２８との結合に一方向異方性を付与し、また強磁性体膜２６に一軸異方性を付与した。ハード膜２３は$Co_{90}Fe_{10}$強磁性体膜２６を単磁区化させる役割を果たす。

【００３２】得られた磁気抵抗効果素子に外部から磁界を印加して、その磁界応答性を調べた。その結果、上部磁性層に$Co_{90}Fe_{10}$強磁性体膜のみを用いた磁気抵抗効果素子と同等以上の安定した出力が得られた。また、磁壁移動に伴うバルクハウゼンノイズの発生は認められなかった。

【００３３】

【発明の効果】以上詳述したように本発明の交換結合膜では大きな交換結合力が得られ、熱安定性にも優れている。また、このような交換結合膜を具備した本発明の磁気抵抗効果素子では安定した出力を長期間にわたって得ることができ、その工業的価値は大なるものがある。

【図面の簡単な説明】

【図１】本発明に係る交換結合膜の一例を示す断面図。

【図２】本発明の実施例１で得られた交換結合膜の磁化曲線を示す図。

【図３】本発明の実施例１で得られた交換結合膜について交換バイアス磁界の値を示す図。

【図４】本発明の実施例２で得られた交換結合膜について中間膜におけるＰｄの添加量ａと交換バイアス磁界との関係を示す図。

【図５】本発明の実施例２で得られた交換結合膜について中間膜におけるＰｄの添加量ａと中間膜の格子定数との関係を示す図。

【図６】本発明に係る交換結合膜の他の例を示す断面図。

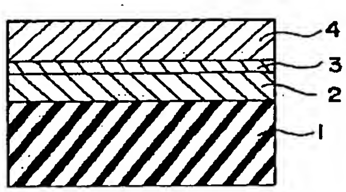
【図７】本発明の実施例５で得られた交換結合膜について交換バイアス磁界の値を示す図。

【図８】本発明に係る磁気抵抗効果素子の一例を示す断面図。

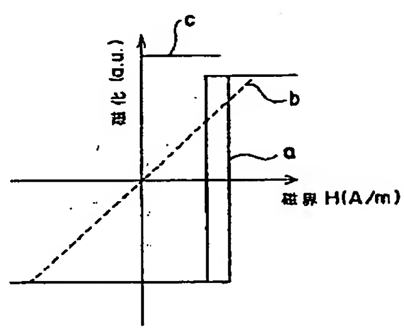
【符号の説明】

１…サファイア基板、２…強磁性体膜、３…中間膜、４…反強磁性体膜、１１、１２…中間膜、２１…シリコン基板、２２…熱酸化膜、２３…$Co_{83}Pt_{17}$ハード膜、２４…$Co_{88}Zr_{5}Nb_{7}$膜、２５…$Ni_{80}Fe_{20}$膜、２６…$Co_{90}Fe_{10}$強磁性体膜、２７…Ｃｕ膜、２８…$Co_{90}Fe_{10}$強磁性体膜、２９…（$Co_{0.9}Fe_{0.1}$）$_{90}Pb_{10}$中間膜、３０…$Fe_{50}Mn_{50}$反強磁性体膜、３１…Ｔｉ保護膜、３２…Ｃｕ電極。

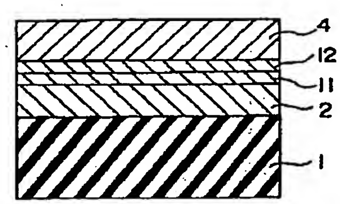
【図１】



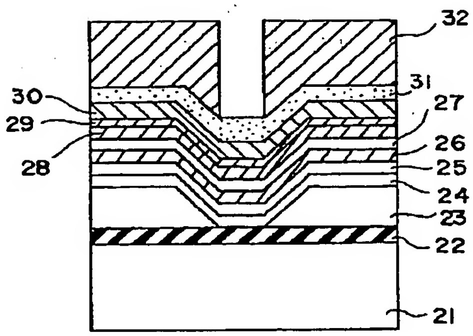
【図２】



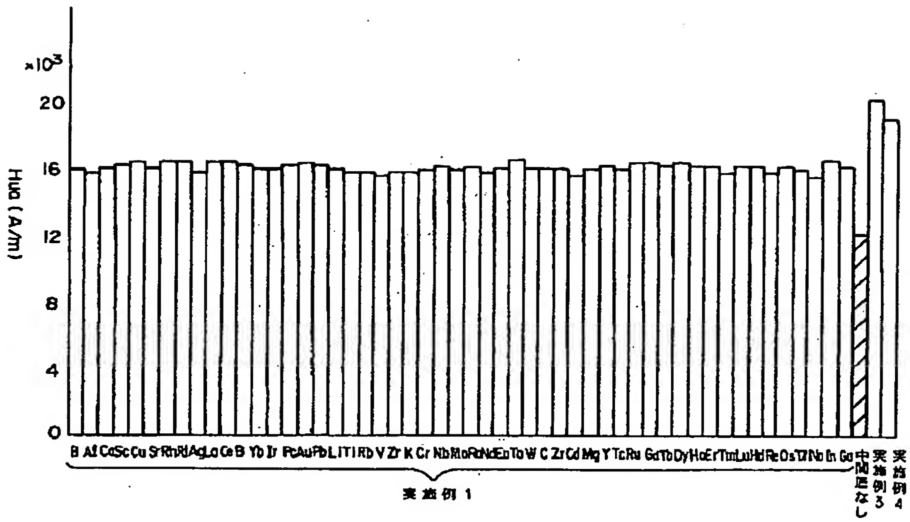
【図６】



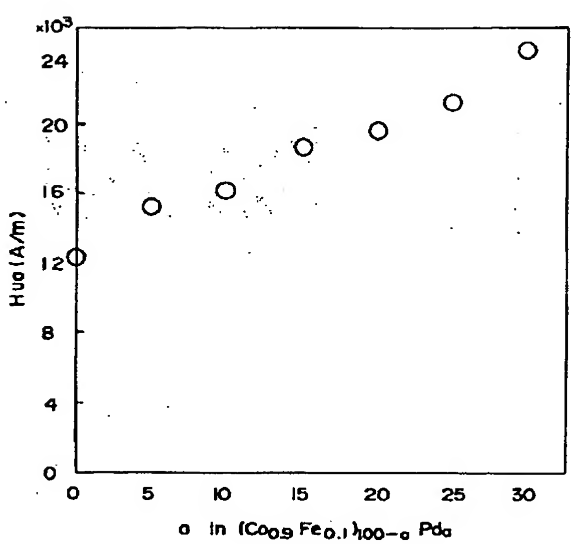
【図８】



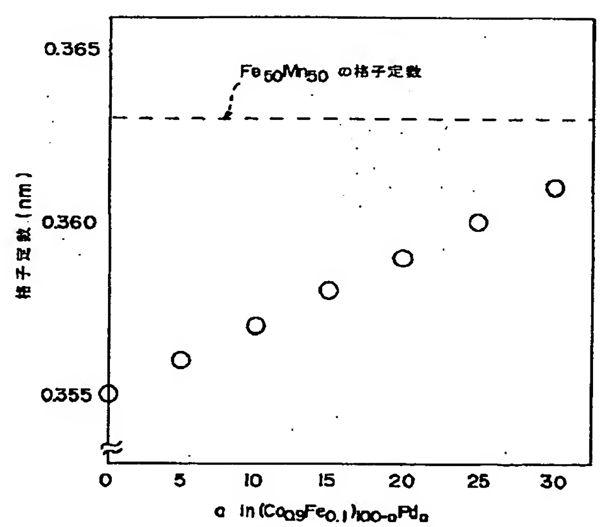
【図3】


×10^3
Hua (A/m)
20
16
12
8
4
0
実施例1
中間層なし
実施例3
実施例4

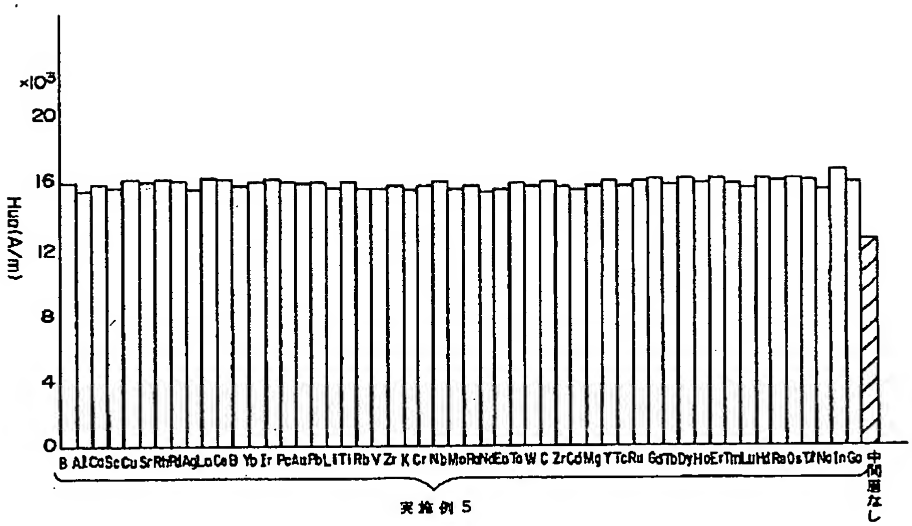
【図4】


×10^3
Hua (A/m)
24
20
16
12
8
4
0
0 5 10 15 20 25 30
a in (Co0.9 Fe0.1)100−a Pda

【図5】


Fe50Mn50 の格子定数
格子定数 (nm)
0.365
0.360
0.355
0 5 10 15 20 25 30
a in (Co0.9Fe0.1)100-aPda

【図７】



フロントページの続き

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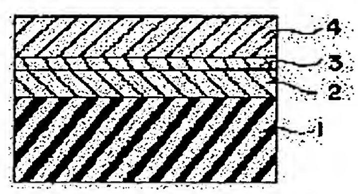
(54) EXCHANGE COUPLING FILM AND MAGNETORESISTANCE EFFECT ELEMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an exchange coupling film with large exchange coupling force, and a magnetoresistance effect element with a stable output for a long time using the exchange coupling film.
SOLUTION: In an exchange coupling film, a ferromagnetic film 2 made of at least one kind of Fe, Co and Ni and an antiferromagnetic film 4 are laminated. A middle film 3 made of a doped ferromagnetic material is provided at the interface between the ferromagnetic film 2 and the antiferromagnetic film 4 to improve the exchange coupling force by improving lattice matching. In addition an electrode for feeding power to the ferromagnetic film 2 in the exchange coupling film is provided.



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CLAIMS

[Claim(s)]
[Claim 1] In the switched connection film which has the structure which carried out the laminating of the ferromagnetic film which consists of at least one sort of elements chosen from the group which consists of Fe, Co, and nickel, and the antiferromagnetic substance film At least one sort of elements chosen from the group which becomes the interface of the above-mentioned ferromagnetic film and the above-mentioned antiferromagnetic substance film from Fe, Co, and nickel, B, aluminum, calcium, Sc, Cu, Sr, Rh, Pd, Ag, La, Ce, Pr, Yb, Ir, Pt, Au, Pb, Li, Ti, Rb, V, Zr, K, Cr, Nb, Mo, Ba, Nd, Eu, Ta, W, C, Zr, Cd, Mg, Y, Tc, Ru, Gd, Tb, Dy, Ho, Switched connection film characterized by making the interlayer which consists of a ferromagnetic containing at least one sort of elements chosen from the group which consists of Er, Tm, Lu, Hf, Re, Os, Tl, Na, In, and Ga intervene.
[Claim 2] The interlayer between which the interface of the above-mentioned ferromagnetic film and the above-mentioned antiferromagnetic substance film is made to be placed is following general formula (CoX FeY NiZ) 100-a Ma (here). It is 0<=X<=1, 0<=Y<=1, 0<=Z<=1, X+Y+Z=1, and 0<=a<=50. M B, aluminum, calcium, Sc, Cu, Sr, Rh, Pd, Ag, La, Ce, Pr, Yb, Ir, Pt, Au, Pb, Li, Ti, Rb, V, Zr, K, Cr, Nb, Mo, Ba, Nd, Eu, Ta, W, C, Zr, Cd, Mg, Y, Tc, Ru, Gd, Tb, Dy, they are at least one sort of elements chosen from the group which consists of Ho, Er, Tm, Lu, HfRe, and Os, Tl, Na, In and Ga. Switched connection film according to claim 1 characterized by what is expressed.
[Claim 3] Switched connection film according to claim 1 characterized by the presentation of the above-mentioned interlayer changing continuously.
[Claim 4] Switched connection film according to claim 1 characterized by the presentation of the above-mentioned interlayer changing gradually.
[Claim 5] The magneto-resistive effect component characterized by providing the electrode which energizes a current on the switched connection film according to claim 1 and the ferromagnetic film which constitutes the above-mentioned switched connection film.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to magneto-resistive effect components, such as switched connection film using the switched connection of the ferromagnetic film and the antiferromagnetic substance film, and a sensor for field detection possessing this switched connection film, the magnetic head for playback.
[0002]
[Description of the Prior Art] Research of the magnetic head using the magneto-resistive effect component as a head for playback in high density magnetic recording is advanced from before. As current and a magneto-resistive effect component ingredient, the 80at%nickel-20at%Fe alloy (so-called permalloy) thin film is used. In recent years, artificial grid film and spin bulb film, such as n which shows giant magneto-resistance as an ingredient which replaces this (Co/Cu), attract attention. However, since the magneto-resistive effect film which consists of these ingredients has a magnetic domain, after that the Barkhausen noise resulting from this puts in practical use, it has been a big problem, and the approach of single-domain-izing the magneto-resistive effect film is examined variously. There is the approach of controlling the magnetic domain of the magneto-resistive effect film in the specific direction to one of them using the switched connection of the magneto-resistive effect film and antiferromagnetic substance film which are a ferromagnetic. As such an antiferromagnetic substance ingredient, the gamma-FeMn alloy is known widely (for example, U.S. Pat. No. 4103315 and U.S. Pat. No. 5014147). Moreover, in the spin bulb film with which giant magneto-resistance is obtained, the antiferromagnetic substance film plays the role which fixes magnetization of the ferromagnetic film which touches this. The magnitude of the fixed force of this magnetization, i.e., the switched connection force, comes to the magnitude of the playback output in the magnetic head which used the spin bulb film for the reproducing-head section as Seki greatly. However, in the combination of the ferromagnetic film and antiferromagnetic substance film which are used by current, there were problems — the big switched connection force is not acquired and, as a result, sufficient playback output is not obtained.
[0003]
[Problem(s) to be Solved by the Invention] As mentioned above, although the switched connection film using the switched connection of the ferromagnetic film and the antiferromagnetic substance film was applied to reduction of the Barkhausen noise of for example, a magneto-resistive effect component, fixing of magnetization of the spin bulb film, etc., it had the problem that so big the switched connection force was not acquired.
[0004] The purpose of this invention is to offer the magneto-resistive effect component which has the switched connection film with which the big switched connection force is acquired, and such switched connection film, and can obtain the stable output over a long period of time.
[0005]
[Means for Solving the Problem] In the switched connection film which has the structure which carried out the laminating of the ferromagnetic film which consists of at least one sort of elements chosen from the group which the switched connection film of this invention becomes from Fe, Co, and nickel, and the antiferromagnetic substance film At least one sort of elements chosen from the group which becomes the interface of the above-mentioned ferromagnetic film and the above-mentioned antiferromagnetic substance film from Fe, Co, and nickel, B, aluminum, calcium, Sc, Cu, Sr, Rh, Pd, Ag, La, Ce, Pr, Yb, Ir, Pt, Au, Pb, Li, Ti, Rb, V, Zr, K, Cr, Nb, Mo, Ba, Nd, Eu, Ta, W, C, Zr, Cd, Mg, Y, Tc, Ru, Gd, Tb, Dy, Ho, It is characterized by making the interlayer which consists of a ferromagnetic containing at least one sort of elements chosen from the group which consists of Er, Tm, Lu, Hf, Re, Os, Tl, Na, In, and Ga intervene. The magneto-resistive effect component of this invention is characterized by providing the electrode which energizes a current on the above-mentioned switched connection film and the ferromagnetic film which constitutes the above-mentioned switched connection film.
[0006]
[Embodiment of the Invention] Hereafter, this invention is explained to a detail. In the switched connection film of this invention, the ferromagnetic film consists of at least one sort of elements chosen from the group which consists of Fe, Co, and nickel, and is expressed with a general formula CoX FeYNiZ (0<=X<=1, 0<=Y<=1, 0<=Z<=1, X+Y+Z=1). More specifically, Co0.9 Fe0.1, nickel0.8 Fe0.2, Co, etc. are mentioned. In the switched connection film of this invention, for example, a gamma-FeMn alloy, NiO, a NiMn alloy, and an IrMn alloy are mentioned as antiferromagnetic substance film. What is necessary is to carry out a laminating partially [these ferromagnetic film and antiferromagnetic substance film] at least, and just to carry out switched connection.
[0007] Having prepared the interlayer which consists of ferromagnetic film containing at least one sort of elements

chosen from the group which becomes the interface of the ferromagnetic film and the antiferromagnetic substance film from Fe, Co, and nickel which are the configuration element of a ferromagnetic, and alloying elements M other than this has the characteristic configuration of the switched connection film of this invention. Here as an alloying element M B, aluminum, calcium, Sc, Cu, Sr, Rh, Pd, Ag, La, Ce, Pr, Yb, Ir, Pt, Au, Pb, Li, Ti, Rb, V, Zr, K, Cr, Nb, Mo, Ba, Nd, Eu, Ta, W, C, Zr, Cd, Mg, Y, Tc, Ru, Gd, Tb, Dy, Ho, At least one sort chosen from the group which consists of Er, Tm, Lu, Hf, Re, Os, Tl, Na, In, and Ga is used.

[0008] The ferromagnetic which constitutes this interlayer is expressed with following general formula (CoX FeY NiZ) 100-a Ma (here, it is 0<=X<=1, 0<=Y<=1, 0<=Z<=1, X+Y+Z=1, and 0<=a<=50.). more -- concrete -- 100(Co0.9 Fe0.1)-a Ma, 100(nickel0.8 Fe0.2)-a Ma, Co100-a Ma, and Fe100-a Ma etc. -- it is mentioned. The addition a of an alloying element M is less than [50at%], and it is more desirable that it is less than [more than 2at%30at%].

[0009] This interlayer has the operation which raises grid matching between film by being placed between the interface of the ferromagnetic film and the antiferromagnetic substance film, and the big switched connection force is acquired by this. The alloying element M mentioned above is a component desirable also for an improvement of corrosion resistance, the switched connection force, and blocking temperature. Especially the inside Pd, Cu, Pt, Au, and Ag of the alloying element mentioned above is a desirable element from a viewpoint suppressed by the minimum in the effect to resistance rate of change.

[0010] As long as an interlayer fulfills the conditions that grid matching becomes good, in an interface with the antiferromagnetic substance film in this invention, you may be a presentation modulation mold. For example, the presentation of an alloying element M may change continuously into an interlayer, and you may change gradually by predetermined thickness. In this case, in the interface by the side of the antiferromagnetic substance film, the addition of an alloying element M should just be max. If element addition is generally performed on the ferromagnetic film, magnetization will decrease, or Curie temperature will fall, but if it controls so that the addition of an alloying element M becomes max in the interface by the side of the antiferromagnetic substance film as mentioned above, degradation of the property of the ferromagnetic film can be suppressed to the minimum. Moreover, the gestalt which carried out the two or more sort laminating of the ferromagnetic of this invention is sufficient.

[0011] By the switched connection film of this invention, the thickness of the ferromagnetic film and the antiferromagnetic substance film will not be limited, especially if it is the range which discovers ferromagnetism and antiferromagnetism, respectively. However, in order to acquire the big switched connection force, it is desirable for the thickness of the antiferromagnetic substance film to be thicker than the thickness of the ferromagnetic film. Moreover, especially the thickness of an interlayer is not limited, either but only at least 1 atomic layer should exist.

[0012] the switched connection film of this invention -- vacuum deposition, a spatter, and MBE -- it is formed on a predetermined substrate using the well-known membrane formation approaches, such as law. Under the present circumstances, in order to give an one direction anisotropy to association with the antiferromagnetic substance film and the ferromagnetic film, membranes may be formed in a field or you may heat-treat.

[0013] Especially a substrate is not limited but can use single crystal substrates, such as amorphous substrates, such as glass and resin, Si, MgO and aluminum 2O3, and various ferrites, an orientation substrate, a sintered carrier, etc. Moreover, in order to raise the crystallinity of the antiferromagnetic substance film or the ferromagnetic film, a substrate layer with a thickness of 1-100nm may be prepared on a substrate. Although it will not be limited especially if a substrate layer raises crystallinity, a metal and an alloy with amorphous metals, such as noble metals, such as Pd and Pt, and CoZrNb, and face centered cubic structure can be used, for example.

[0014] The magneto-resistive effect component of this invention prepares the electrode for energizing a current on the ferromagnetic film at least to the switched connection film mentioned above. As an electrode, Cu, Ag, Au, aluminum, and these alloys are used, for example. An electrode may contact the ferromagnetic film directly and may be formed through the antiferromagnetic substance film.

[0015] Since the magneto-resistive effect component of this invention possesses the switched connection film with which the big switched connection force is acquired as mentioned above, when it uses for the sensor for field detection, the magnetic head for playback, etc., a big playback output is obtained.

[0016] In addition, in the magneto-resistive effect component of this invention, the switched connection force of the antiferromagnetic substance film and the ferromagnetic film is also applicable to magnetization fixing over the Barkhausen noise removal, artificial grid film, and spin bulb film in the ferromagnetic film etc.

[0017]

[Example] Hereafter, the example of this invention is explained with reference to a drawing.

The switched connection film which has the structure shown in drawing 1 was produced by forming membranes among a field in the condition of not heating the substrate, using example 1RF magnetron sputtering equipment. Specifically, the front face carried out sequential formation of the ferromagnetic film 2 of 4nm of thickness which has the presentation of Co90Fe10 on the silicon on sapphire 1 which is C side, the interlayer 3 of 1nm of thickness which it becomes from the ferromagnetic which has the presentation expressed with 90(Co0.9 Fe0.1) M10, and the antiferromagnetic substance film 4 of 15nm of thickness which has the presentation of Fe50Mn50. As an alloying element M of an interlayer 3 Respectively B, aluminum, calcium, Sc, Cu, Sr, Rh, Pd, Ag, La, Ce, Pr, Yb, Ir, Pt, Au, Pb, Li, Ti, Rb, V, Zr, K, Cr, Nb, Mo, Ba, Nd, Eu, Ta, W, C, Zr, Cd, Mg, Y, Tc, Ru, Gd, Tb, Dy, Ho, Er, Tm, Lu, Hf, Re, Os, Tl, Na, In, or Ga was used.

[0018] About the obtained switched connection film, the crystal structure and its orientation bearing were investigated according to the X diffraction. Consequently, the crystal structure is face centered cubic structure, and it was checked that it is the film which carried out orientation (111).

[0019] The magnetization curve a of the direction of an easy axis of the switched connection film obtained by drawing 2 (the direction of a field at the time of membrane formation) and the magnetization curve b of the direction of a hard axis are shown. In drawing 2 , the value of c is the exchange bias field (Hua) which shows the switched connection force.
[0020] The value of the exchange bias field measured about the switched connection film which has not prepared each switched connection film which has the interlayer which added each alloying element M mentioned above, and an interlayer in drawing 3 is shown. As shown in this drawing, the switched connection film which has an interlayer is understood that the switched connection force is larger than the switched connection film which has not prepared the interlayer.
[0021] The switched connection film which has the structure shown in drawing 1 by the same approach as example 2 example 1 was produced. In this example, the front face carried out sequential formation of the ferromagnetic film 2 of 3nm of thickness which has the presentation of Co90Fe10 on the silicon on sapphire 1 which is C side, the interlayer 3 of 2nm of thickness which it becomes from the ferromagnetic which has the presentation expressed with 100(Co0.9 Fe0.1)-a Pda (a= 5, 10, 15, 20, 25, 30), and the antiferromagnetic substance film 4 of 15nm of thickness which has the presentation of Fe50Mn50.
[0022] The relation of the addition a of Pd and exchange bias field in an interlayer is shown in drawing 4 . Drawing 4 shows that the switched connection force increases in connection with the addition a of Pd increasing.
[0023] The relation of the addition a of Pd and the lattice constant of an interlayer in an interlayer is shown in drawing 5 . Drawing 5 shows approaching the lattice constant of Fe50Mn50 whose lattice constant of an interlayer is the antiferromagnetic substance film in connection with the addition a of Pd increasing.
[0024] The switched connection film which has the structure shown in drawing 6 by the same approach as example 3 example 1 was produced. In this example on silicon on sapphire 1 The presentation of Co90Fe10 Ferromagnetic film 2 () of 4nm of thickness which it has, [Co0.9] The presentation expressed with Fe0.1 90Ta10 Sequential formation of the interlayer 11 of 1.5nm of thickness which consists of a ferromagnetic which it has, the interlayer 12 of 1.5nm of thickness which consists of a ferromagnetic which has the presentation expressed with 80(Co0.9 Fe0.1) Ta20, and the antiferromagnetic substance film 4 of 15nm of thickness which has the presentation of Fe50Mn50 was carried out.
[0025] The value of the exchange bias field of the switched connection film obtained by drawing 3 by this example is written together. When a presentation uses as an interlayer the presentation modulation film which changes gradually like this example, it turns out that the big switched connection force is acquired.
[0026] The switched connection film which has structure similar to drawing 1 by the same approach as example 4 example 1 was produced. The ferromagnetic film 2 of 2nm of thickness which has the presentation of Co90Fe10 on silicon on sapphire 1 in this example, and 100(Co0.9 Fe0.1)-a Nda It has the presentation expressed. Sequential formation of the interlayer 3 of 3nm of thickness which consists of a ferromagnetic continuously changed so that the Nd presentation a might be set to a= 20 by the a= 1 and antiferromagnetic substance film 4 side by the ferromagnetic film 2 side, and the antiferromagnetic substance film 4 of 15nm of thickness which has the presentation of Fe50Mn50 was carried out.
[0027] The value of the exchange bias field of the switched connection film obtained by drawing 3 by this example is written together. When a presentation uses as an interlayer the presentation modulation film which changes continuously like this example, it turns out that the big switched connection force is acquired.
[0028] The switched connection film which has the structure shown in drawing 1 by the same approach as example 5 example 1 was produced. In this example, the front face carried out sequential formation of the ferromagnetic film 2 of 4nm of thickness which has the presentation of nickel80Fe20 on the silicon on sapphire 1 which is C side, the interlayer 3 of 1nm of thickness which it becomes from the ferromagnetic which has the presentation expressed with 90(nickel0.8 Fe0.2) M10, and the antiferromagnetic substance film 4 of 15nm of thickness which has the presentation of Fe50Mn50. As an alloying element M of an interlayer 3 Respectively B, aluminum, calcium, Sc, Cu, Sr, Rh, Pd, Ag, La, Ce, Pr, Yb, Ir, Pt, Au, Pb, Li, Ti, Rb, V, Zr, K, Cr, Nb, Mo, Ba, Nd, Eu, Ta, W, C, Zr, Cd, Mg, Y, Tc, Ru, Gd, Tb, Dy, Ho, Er, Tm, Lu, Hf, Re, Os, Tl, Na, In, or Ga was used.
[0029] The value of the exchange bias field measured about the switched connection film which has not prepared each switched connection film which has the interlayer which added each alloying element M mentioned above, and an interlayer in drawing 7 is shown. As shown in this drawing, the switched connection film which has an interlayer is understood that the switched connection force is larger than the switched connection film which has not prepared the interlayer.
[0030] In example 6 this example, it was processed using the usual semi-conductor process, and the magneto-resistive effect component shown in drawing 8 was produced. On the thermal oxidation film 22 formed in silicon substrate 21 front face, after forming the Co83Pt17 hard film 23 of 40nm of thickness, the part was removed alternatively and, specifically, the thermal oxidation film 22 of a substrate was exposed partially. On it Co88Zr5 Nb7 of 10nm of thickness The film 24, nickel80Fe20 film 25 of 2nm of thickness, the Co90Fe10 ferromagnetic film 26 of 4nm of thickness, the Cu film 27 of 3nm of thickness, the Co90Fe10 ferromagnetic film 28 of 2nm of thickness, 90 (Co0.9 Fe0.1) Pb10 interlayer 29 of 1nm of thickness, Sequential membrane formation of the Fe50Mn50 antiferromagnetic-substance film 30 of 15nm of thickness and the Ti protective coat 31 of 20nm of thickness was carried out. Furthermore, the Cu electrode 32 of 20 micrometers of thickness was formed and processed.
[0031] In addition, after heat-treating in a field, the hard film 23 was magnetized, and the one direction anisotropy was given to association with the antiferromagnetic substance film 30, an interlayer 29, and the ferromagnetic film

28, and uniaxial anisotropy was given to the ferromagnetic film 26. The hard film 23 plays the role which makes the Co90Fe10 ferromagnetic film 26 single-domain-ize.

[0032] The field was impressed to the obtained magneto-resistive effect component from the exterior, and the field responsibility was investigated. Consequently, the output by which it was stabilized more than the magneto-resistive effect component which used only the Co90Fe10 ferromagnetic film for the up magnetic layer, and the EQC was obtained. Moreover, generating of the Barkhausen noise accompanying domain wall displacement was not accepted.

[0033]

[Effect of the Invention] As explained in full detail above, the big switched connection force is acquired and it excels in the switched connection film of this invention also at thermal stability. Moreover, with the magneto-resistive effect component of this invention possessing such switched connection film, the stable output can be obtained over a long period of time, and a so-called size has the industrial value.

[Translation done.]

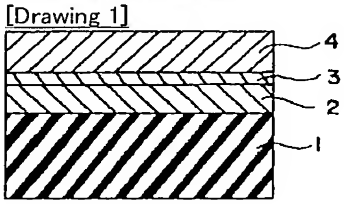
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The sectional view showing an example of the switched connection film concerning this invention.
[Drawing 2] Drawing showing the magnetization curve of the switched connection film obtained in the example 1 of this invention.
[Drawing 3] Drawing showing the value of an exchange bias field about the switched connection film obtained in the example 1 of this invention.
[Drawing 4] Drawing showing the relation of the addition a of Pd and exchange bias field in an interlayer about the switched connection film obtained in the example 2 of this invention.
[Drawing 5] Drawing showing the relation of the addition a of Pd and the lattice constant of an interlayer in an interlayer about the switched connection film obtained in the example 2 of this invention.
[Drawing 6] The sectional view showing other examples of the switched connection film concerning this invention.
[Drawing 7] Drawing showing the value of an exchange bias field about the switched connection film obtained in the example 5 of this invention.
[Drawing 8] The sectional view showing an example of the magneto-resistive effect component concerning this invention.
[Description of Notations]
1 [-- Antiferromagnetic substance film,] -- Silicon on sapphire, 2 -- The ferromagnetic film, 3 -- An interlayer, 4 11 12 [-- Co83Pt17 hard film,] -- An interlayer, 21 -- A silicon substrate, 22 -- The thermal oxidation film, 23 24 -- Co88Zr5 Nb7 The film, 25 -- nickel80Fe20 film, 26 -- Co90Fe10 ferromagnetic film, 27 [-- The Fe50Mn50 antiferromagnetic-substance film, 31 / -- Ti protective coat, 32 / -- Cu electrode.] -- Cu film, 28 -- The Co90Fe10 ferromagnetic film, 29 -- (Co0.9 Fe0.1) 90Pb10 interlayer, 30

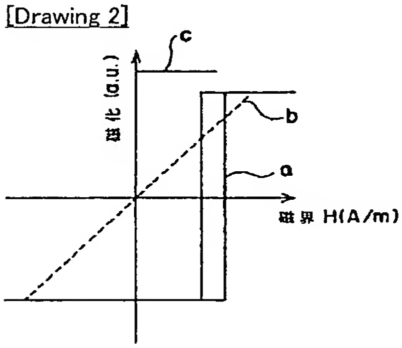
[Translation done.]

DRAWINGS

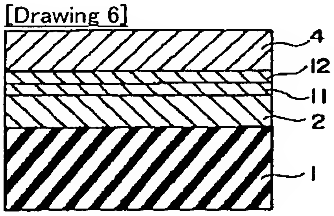
[Drawing 1]



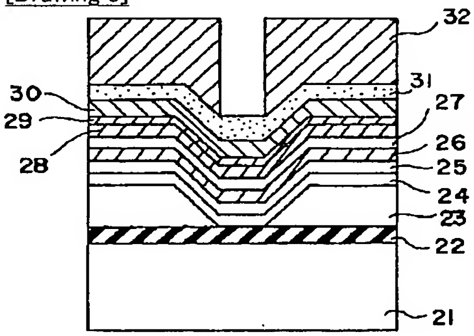
[Drawing 2]



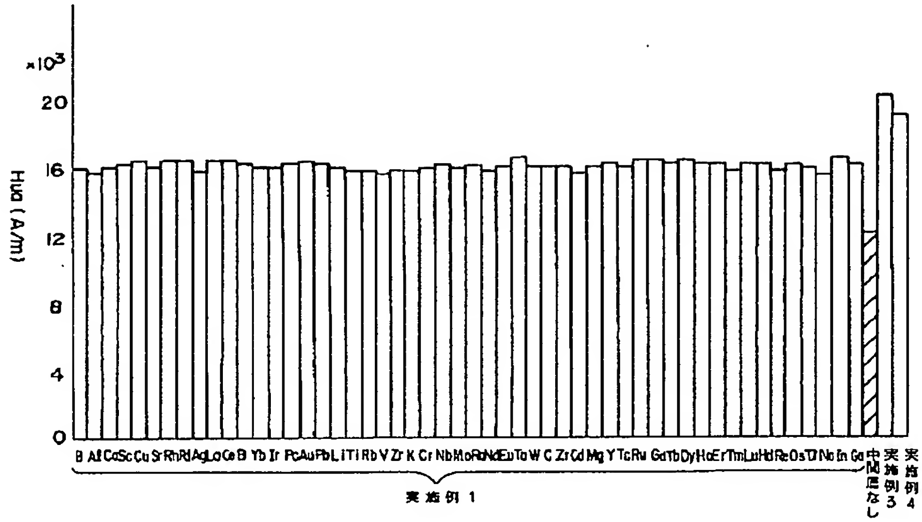
[Drawing 6]



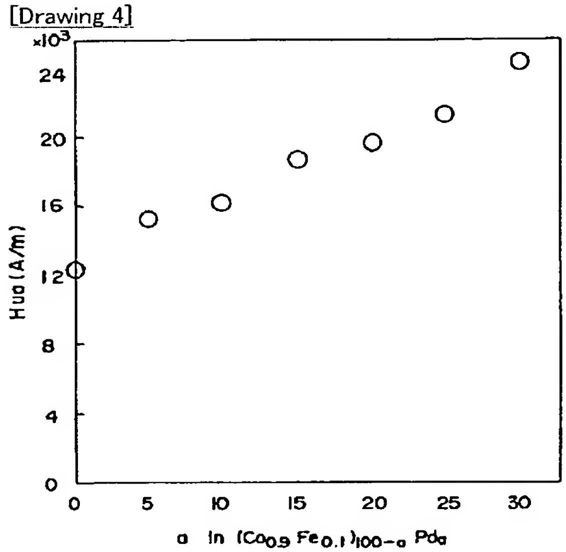
[Drawing 8]



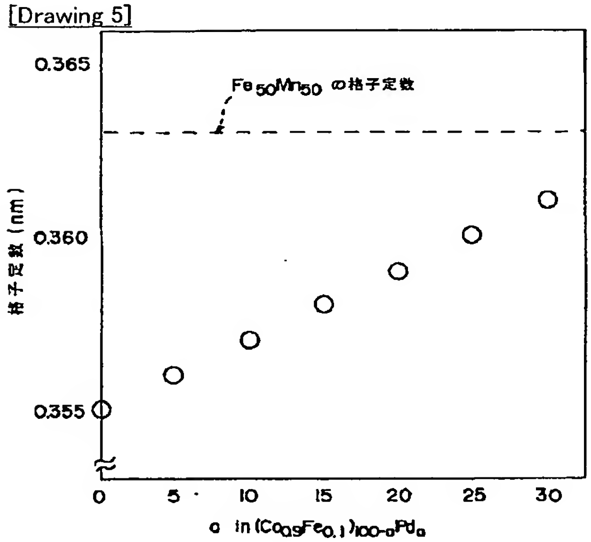
[Drawing 3]



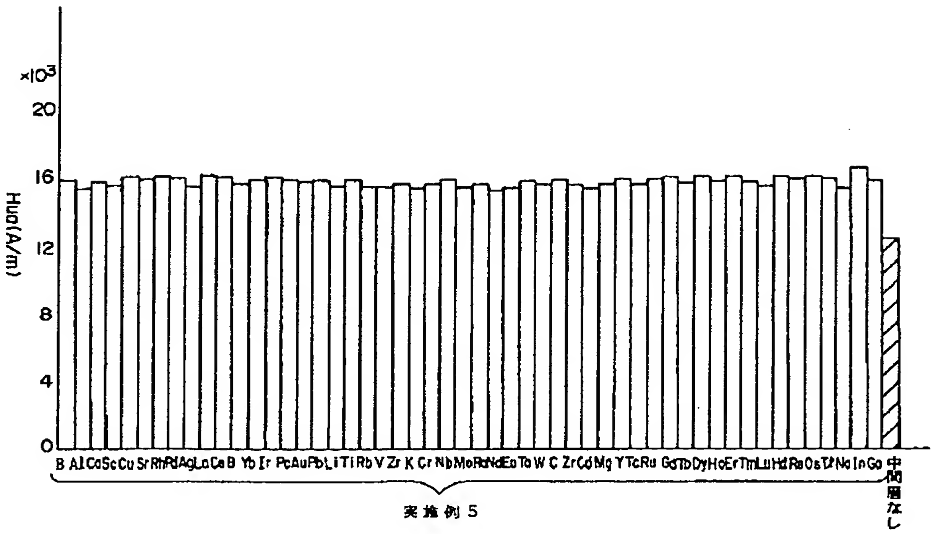
[Drawing 4]



[Drawing 5]



[Drawing 7]



[Translation done.]

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[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] The name of invention
[Method of Amendment] Modification
[Proposed Amendment]
[Title of the Invention] The switched connection film, a magneto-resistive effect component, and a magneto-resistive effect head
[Procedure amendment 2]
[Document to be Amended] Specification
[Item(s) to be Amended] Claim
[Method of Amendment] Modification
[Proposed Amendment]
[Claim(s)]
[Claim 1] Ferromagnetic film which consists of at least one sort of elements chosen from the group which consists of Fe, Co, and nickel Structure which carried out the laminating of the antiferromagnetic substance film At least one sort of elements chosen from the group which is the switched connection film equipped with the above, and becomes the interface of the above-mentioned ferromagnetic film and the above-mentioned antiferromagnetic substance film from Fe, Co, and nickel, B, aluminum, calcium, Sc, Cu, Sr, Rh, Pd, Ag, La, Ce, Pr, Yb, Ir, Pt, Au, Pb, Li, Ti, Rb, V, Zr, K, Cr, Nb, Mo, Ba, Nd, Eu, Ta, W, C, Zr, Cd, Mg, Y, Tc, Ru, Gd, Tb, Dy, Ho, It is characterized by making the interlayer which consists of a ferromagnetic containing at least one sort of elements chosen from the group which consists of Er, Tm, Lu, Hf, Re, Os, Tl, Na, In, and Ga intervene.
[Claim 2] The interlayer between which the interface of the above-mentioned ferromagnetic film and the above-mentioned antiferromagnetic substance film is made to be placed is the following general formula.
(CoX FeY NiZ)100-a Ma
(It is 0<=X<=1, 0<=Y<=1, 0<=Z<=1, X+Y+Z=1, and 0<=a<=50 here.) M B, aluminum, calcium, Sc, Cu, Sr, Rh, Pd, Ag, La, Ce, Pr, Yb, Ir, Pt, Au, Pb, Li, Ti, Rb, V, Zr, K, Cr, Nb, Mo, Ba, Nd, Eu, Ta, W, C, Zr, Cd, Mg, Y, Tc, Ru, Gd, Tb, Dy, they are at least one sort of elements chosen from the group which consists of Ho, Er, Tm, Lu, HfRe, and Os, Tl, Na, In and Ga.

Switched connection film according to claim 1 which comes out and is characterized by what is expressed.
[Claim 3] Switched connection film according to claim 1 characterized by the presentation of the above-mentioned interlayer changing continuously.
[Claim 4] Switched connection film according to claim 1 characterized by the presentation of the above-mentioned interlayer changing gradually.
[Claim 5] The magneto-resistive effect component characterized by providing the following. Ferromagnetic film which consists of at least one sort of elements chosen from the group which consists of Fe, Co, and nickel Antiferromagnetic substance film At least one sort of elements chosen from the group which it has the interlayer by which it is placed between the interfaces of the above-mentioned ferromagnetic film and the above-mentioned antiferromagnetic substance film, and the above-mentioned interlayer becomes from Fe, Co, and nickel B, aluminum, calcium, Sc, Cu, Sr, Rh, Pd, Ag, La, Ce, Pr, Yb, Ir, Pt, Au, Pb, Li, Ti, Rb, V, Zr, K, Cr, Nb, Mo, Ba, Nd, Eu, Ta, W, C, Zr, Cd, Mg, Y, Tc, Ru, Gd, Tb, Dy, Ho, The electrode which energizes a current on the switched connection film which consists of a ferromagnetic containing at least one sort of elements chosen from the group which consists of Er, Tm, Lu, Hf, Re, Os, Tl, Na, In, and Ga, and the ferromagnetic film which constitutes the above-mentioned switched connection film
[Claim 6] The magneto-resistive effect component characterized by providing the following. At least one sort of elements chosen from the group to which it has the ferromagnetic film, the non-magnetic-material film, the ferromagnetic film, an interlayer, and a cascade screen containing the antiferromagnetic substance film, and the antiferromagnetic substance film and ferromagnetic film which adjoin on both sides of the above-mentioned interlayer are carrying out switched connection, and which the above-mentioned interlayer becomes from Fe, Co, and nickel B, aluminum, calcium, Sc, Cu, Sr, Rh, Pd, Ag, La, Ce, Pr, Yb, Ir, Pt, Au, Pb, Li, Ti, Rb, V, Zr, K, Cr, Nb, Mo, Ba, Nd, Eu, Ta, W, C, Zr, Cd, Mg, Y, Tc, Ru, Gd, Tb, Dy, Ho, The electrode which consists of a ferromagnetic containing at least one sort of elements chosen from the group which consists of Er, Tm, Lu, Hf, Re, Os, Tl, Na, In, and Ga, and energizes a current to said cascade screen
[Claim 7] The above-mentioned interlayer is the following general formula.
(CoX FeY NiZ)100-a Ma
(It is 0<=X<=1, 0<=Y<=1, 0<=Z<=1, X+Y+Z=1, and 0<=a<=50 here.) M B, aluminum, calcium, Sc, Cu, Sr, Rh, Pd, Ag, La, Ce, Pr, Yb, Ir, Pt, Au, Pb, Li, Ti, Rb, V, Zr, K, Cr, Nb, Mo, Ba, Nd, Eu, Ta, W, C, Zr, Cd, Mg, Y, Tc, Ru, Gd, Tb, Dy, they are at least one sort of elements chosen from the group which consists of Ho, Er, Tm, Lu, HfRe, and Os, Tl, Na, In and Ga.
The magneto-resistive effect component according to claim 5 or 6 which comes out and is characterized by what is expressed.
[Claim 8] The magneto-resistive effect component according to claim 5 or 6 characterized by the presentation of the above-mentioned interlayer changing continuously.
[Claim 9] The magneto-resistive effect component according to claim 5 or 6 characterized by the presentation of the above-mentioned interlayer changing gradually.
[Claim 10] The magneto-resistive effect component according to claim 5 or 6 characterized by the above-mentioned interlayer consisting of a ferromagnetic containing at least one sort of elements chosen from the group which consists of Pd, Cu, Pt, Au, and Ag.
[Claim 11] It is the magneto-resistive effect component according to claim 6 which magnetization has fixed substantially the ferromagnetic film which carried out switched connection to the above-mentioned antiferromagnetic substance film, and is characterized by magnetization rotating the ferromagnetic film of another side by the external magnetic field.
[Claim 12] Substrate The cascade screen containing the nonmagnetic membrane inserted between the 1st ferromagnetic film formed on the above-mentioned substrate, the 2nd ferromagnetic film, the above 1st, and the 2nd ferromagnetic film, and the antiferromagnetic substance film formed on the ferromagnetic film of the above 1st One pair of electrodes which energize a current to the above-mentioned cascade screen Are the magneto-resistive effect component equipped with the above, and an interlayer is prepared between the ferromagnetic film of the above 1st, and the above-mentioned antiferromagnetic substance film. The above-mentioned interlayer contains at least one sort of elements and at least one sort of alloying elements which are chosen from the group which consists of Co, Fe, and nickel and nickel, and the above-mentioned interlayer is characterized by having the operation which raises grid matching between the above-mentioned antiferromagnetic substance film and the ferromagnetic film of the above 1st.
[Claim 13] The magneto-resistive effect head characterized by claim 5 thru/or providing the magneto-resistive effect component of a publication 12 either.

[Translation done.]